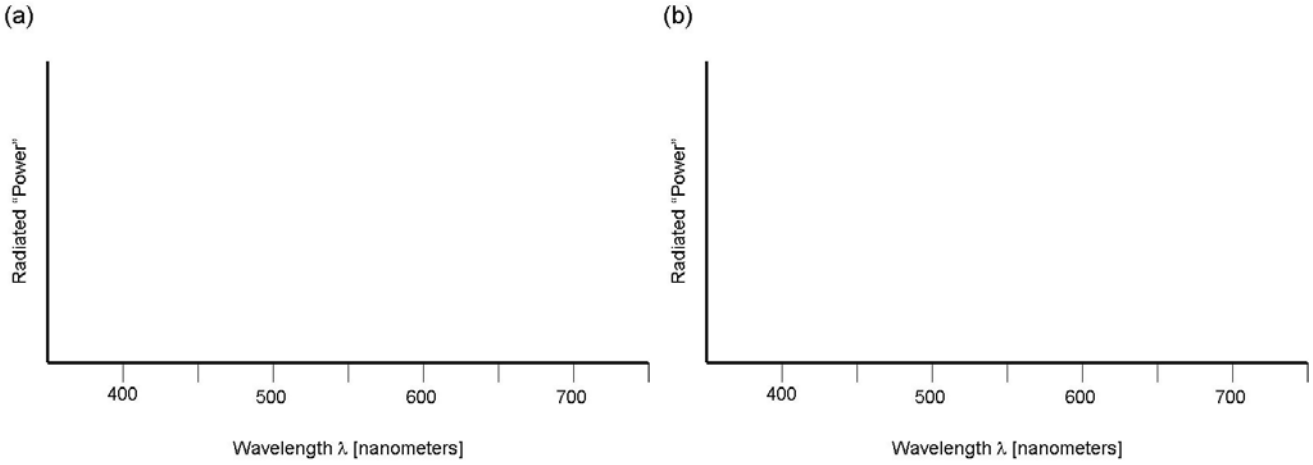
SIMG-215-02 Fundamentals of Imaging Science
12 October 2006

Name_____

Instructions. SELECT and ANSWER SIX QUESTIONS ONLY (out of 8, equal weight). PUT AN "X" THROUGH EACH QUESTION THAT YOU ARE NOT ANSWERING
Allowed materials: One side of one page of notes, lenses from your Optics Discovery Kit, UNPROGRAMMED calculator.
If you need more space for your answer, you may use the back side of the pages, but indicate that you have done so on the front of the page.

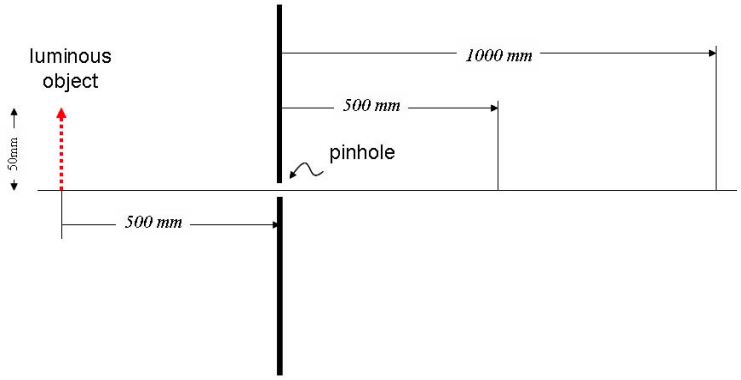
1. On the graph labeled (a), sketch a spectrum of light that might be emitted from a source that emits light by a thermal interaction (e.g., the Sun). On graph (b), sketch the spectrum of light that might be emitted from a source that emits light by an atomic interaction (e.g., a laser). Describe the differences between the two in a sentence or two.



2. The diagram below shows a luminous ("glowing") object and a sheet of opaque material with a small pinhole. The object is 50 mm tall and located 500 mm from the pinhole.

   (a) What are the sizes and orientations of images on observation screens located at distances of (a) 500 mm and (b) 1000 mm from the pinhole? Hint: You may draw appropriate rays from the object to the image on the diagram.

   (b) Describe the advantages and disadvantages that would accrue if the pinhole is very small and if it is enlarged.

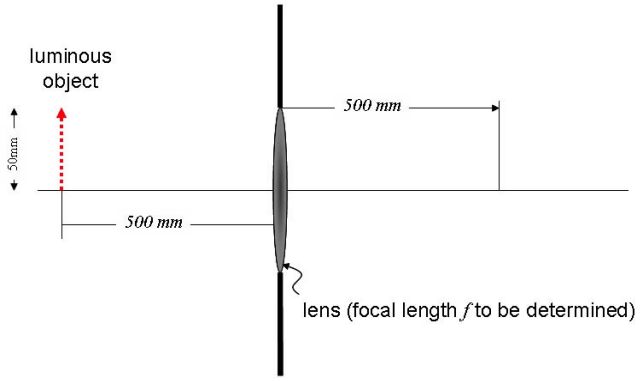


3. The same object used in the previous problem is located 500 mm from a lens.

   (a) What is the focal length f of a lens that will produce an image located 500 mm from the lens?

   (b) What is the magnification M_t of the resulting image?

   (c) (OPTIONAL BONUS) What is the focal length of the lens that will produce a virtual image that twice as large as the object?



4. We discussed *local averaging* and *local differencing* as image processing operations. Briefly describe what these terms mean and tell what imaging operations for which they might be useful.

5. The speed of light propagation in vacuum is $c \cong 3 \times 10^8$ meters per second. The index of refraction of air (at standard temperature and pressure) is $n \cong 1.0003$.

   (a) By what multiplicative factor is the speed of light in air slower than the speed in vacuum? (you need only write down the equation; you need not evaluate to give a number)

   (b) In the early 1600s, Galileo tried to measure the speed of light with two lanterns. He sent a man to a hilltop some distance away at night with one shielded lantern. Galileo uncovered one lantern and the man was instructed to uncover his lantern at the instant when Galileo's light became visible. What is the problem with his experiment? (side comment: Römer used a method based on Galileo's idea to measure the speed of light in the 1670s, except that his method required no second person and the light traveled only one way. This would be a very appropriate topic for a short paper)

6. List three (3) physical interactions that can occur between light energy and matter. For each of these, give an example of how that interaction makes an object "visible" to an imaging system.

7. In your own words, describe how a charge-coupled device (CCD) is able to create and read out an image. Use figures to illustrate your answer

8. We stated that the charge-coupled device (CCD) has almost completely replaced photographic emulsions in astronomical applications and it is clear that this is becoming true in consumer applications (e.g., family snapshots). Explain why these changes are occuring, including several reasons for the change.